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AMIN, TUROCY & CALVIN, LLP
1900 EAST 9TH STREET, NATIONAL CITY CENTER
24TH FLOOR,
CLEVELAND, OH 44114

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BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Application Number: 10/726,992
Filing Date: December 03, 2003
Appellant(s): AVANZINO, STEVEN C.

Gregory Turocy
For Appellant

EXAMINER'S ANSWER

This is in response to the appeal brief filed 3/23/2007 appealing from the Office action mailed 6/5/2006.

(1) Real Party in Interest

A statement identifying by name the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

The examiner is not aware of any related appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

(3) Status of Claims

The statement of the status of claims contained in the brief is correct.

(4) Status of Amendments After Final

No amendment after final has been filed.

(5) Summary of Claimed Subject Matter

The summary of claimed subject matter contained in the brief is correct.

(6) Grounds of Rejection to be Reviewed on Appeal

The appellant's statement of the grounds of rejection to be reviewed on appeal is correct.

(7) Claims Appendix

The copy of the appealed claims contained in the Appendix to the brief is correct.

(8) Evidence Relied Upon

6,261,953,	Uozumi, Yoshihiro	7-2001
6,596,638	Kondo et al.	7-2003

6,719,920	Miller, Anne E.	4-2004
6,547,843	Shimazu et al.	4-2003
6,594,024	Singh et al.	7-2003

(9) Grounds of Rejection

The following ground(s) of rejection are applicable to the appealed claims:

Claims 1,2,3,5,7,8,9,10,11,14 and16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Uozumi (US 6261953) in view of Kondo et al. (US 6596638)

Uozumi discloses a method for etching a copper film or structure, which reads on "the copper containing material comprising at least 10% by weight copper", the method comprises the steps of forming a copper oxide layer by contacting the copper surface with an aqueous hydrogen peroxide containing solution, and then removing the copper oxide from the copper film using an acid containing solution (see column 4 line 7-14), the acid may be organic (column 5, line 15). The benefit of controlling the pH of the oxidizing solution is also addressed in the reference (figure 6). Uozumi clearly teaches two-step copper film etching is conventionally used in the art, the first step modifies a thin layer on the copper surface, the second step removes the modified layer on the copper surface.

A difference is noted between the appellant's claims and the reference of Uozumi. Uozumi's first solution comprises ammonia, hydrogen peroxide and water,

whereas the appellant's first solution comprises a first organic acid, a peroxide compound and water.

Kondo at al. teach an abrasive free polishing method wherein copper is removed using a polishing solution comprising an oxidizer and a substance that renders the oxidized copper water soluble, in particular, a mixture of citric acid and aqueous hydrogen peroxide is cited as being a typical example of a polishing solution (column 5, line 22). The citric acid-based solution is shown (figure 9) to have a pH within the range of 2 to 6. Kondo cites "in the domain of corrosion (pH between less than 7 and oxidation reduction potential greater than 0.2 (column 6, lines 44-46)), copper is rendered water soluble and ionized at a much faster rate than in the domain of passivation (column 5, line 29). Figure 9 also shows that for a minimum oxidation-reduction potential of less than 0.2 the pH of the solution is less than 6, also figure 26 illustrates pH less than 6 is desirable for faster corrosion rate.

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the process of Uozumi to replace the first solution with the solution of Kondo to provide faster etch rate and a wider range of stability for the etch process, as illustrated by a progressive variation of etch rate versus pH (see Kondo, figure 26) , and therefor, better control of the process. The sharp rise in etch rate versus pH for the ammonia-based solution in figure 6 of Uozumi is not desirable for process control. One of ordinary skill in the art would have been motivated to replace the first solution of Uozumi with the solution of Kondo in order to obtain better control of the etch as the pH of the solution may vary with time and use.

Uozumi also differs from the claimed invention by using a second solution comprising an acid (which could be organic), instead of the appellant's second solution which comprises a organic acid (from list in claim 2) and water,

Kondo's teachings also include organic acids are substances that render copper and copper oxide water soluble (column 6, line33, and column 12, line29).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the second solution of Uozumi to use an organic acid to render any byproduct of the first solution water soluble, the second step not comprising a peroxide compound will stabilize the surface from further oxidation, because the reference of Kondo at al. illustrates how organic acids are used in controlled scratch free polishing of copper resulting in a smooth surface.

One of ordinary skill in the art would have been motivated to combine the teachings for a two-step copper etch method and the advantages of organic acids in order to obtain an abrasive free controllable copper etch method that provides scratch free smooth surfaces.

As to claims 3 and 5, a difference is noted between the teachings of Uozumi and appellant's claimed invention. Uozumi's method cited above is silent about the proportions or range of the components in solutions 1 and 2 as described by appellant's claims 3 and 5.

Kondo et al. describe a polishing solution with 30% aqueous H_2O_2, and 0.03 wt % citric acid (column 12, lines 32 and 48) which is included in appellant's claimed ranges. Overlapping ranges are held obvious.

As to claim 7, a difference is noted between the teaching s of Uozumi and appellant's claimed invention. Uozumi's method, cited above, fails to disclose a range for the pH in the first solution specifically consisting of a peroxide compound, an organic acid and water, as the appellant's claim 7.

Kondo et al. disclose the corrosion rate of a polishing solution comprising a mixture of citric acid and aqueous hydrogen peroxide (figure 26, and column 5, line 22). Figure 26 shows that for the citric acid based solution, corrosion rate (etching rate) (column 5, line 17)) is higher when the pH of the solution is in the range of 1 to 6. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the method of Uozumi's, as described above, where solutions 1 and 2 have a pH in the range where oxidation is maximized for solution 1 (pH is about 3 or less for highest corrosion rate according to figure 26 of Kondo), and copper oxide removal is optimized for solution 2 (corrosion rate does not need to be high for the second solution, so a pH of less than 7 is acceptable according to figure 26 of Kondo). Overlapping ranges are held obvious.

As to claim 8, a difference is noted between the teachings of Uozumi and appellant's claimed invention. Uozumi's method, cited above, is silent about an operating temperature range for solutions 1 and 2 as described in appellant's claim 8.

Kondo et al. disclose a polishing solution comprising a mixture of citric acid and aqueous hydrogen peroxide. For the cited example the temperature of the polishing solution was room temperature (column 12, line 37), which is included in the appellant's temperature range. Appellants have not shown anything critical with respect to the

temperature of solutions 1 and 2. In the absence of unexpected results, it would appear that any temperature near standard room temperature would have produced comparable results.

As to claim 9, a difference is noted between the teaching s of Uozumi and appellant's claimed invention. Uozumi's reference fails to specify oxide as a passivation layer.

Kond o et al. discloses an oxide is formed when copper is contacted with a solution where the pH and oxidation-reduction potential are in the domain of corrosion of said metal (column 21, line 5).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify Uozumi, as described above, to include Cu oxide as the passivation because, as taught by Kondo oxide is formed when the pH of the solution and oxidation-reduction potential are in the domain of corrosion of copper.

As to claim 10, Uozumi discloses a method for etching a copper film or structure, which reads on the claimed "the copper containing material comprising at least 25% by weight copper". The limitations [of contacting the copper structure with a first solution to convert at least a portion of the copper structure to a passivating film, the first solution comprising a peroxide compound, a firstorganic acid, and water and having a PH from about 2 to about 6.,contacting the passivating film with a second solution to remove the passivating film, the second solution comprising a second organic acid and water] have been addressed above. As to the limitation citing "the second solution having a lower PH and a higher temperature than the PH and temperature of the first solution" see the

rejections in reference of claims 7 and 8. As to rinsing the wafer, it would have been obvious to one of ordinary skill in the art at the time the invention was made to rinse the wafer after the second step in order to remove any residues and byproducts from the second step.

In addition, and relative to appellant's claim 10, Uozumi discloses that the copper etching rate depends on the solution pH (figure 6). Uozumi also discloses that too high corrosion (oxidation) in the first step results in rougher surface (column 2, line 60).

Kondo et al. teach that, for a citric acid-based solution, the corrosion rate increases with decreasing pH (figure 26).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify Uozumi's method, as described above, to increase the pH of the first solution relative to the second in order to control the corrosion (oxidation) during the first step in order to obtain a smoother surface (the second solution does not rely corrosion to remove the oxide layer).

As for the temperature Uozumi teaches that during the oxidation step, high temperature results in rougher surface as the rate of oxidation increases in the first solution (column 2, line 62).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to use a lower temperature for the first solution, relative to the second solution, to control corrosion in the first step in order to obtain a smoother surface.

As to claim 11, a difference is noted between the teaching s of Uozumi and appellant's claimed invention. Uozumi's method, cited above, is silent about specific proportions of peroxide compound, organic acid, water, surfactant and pH adjuster.

Kondo et al. describe a polishing solution with 30% aqueous H2O2, and 0.03 wt % citric acid (column 12, lines 32 and 48) which is in the in the range of the appellant's claim 11 for the peroxide compound, organic acid, water.

Kondo fails to teach specific proportions for surfactant and pH adjuster but they do illustrate the benefits of adjusting the pH (column 5, line 3) as well as the optional use of surfactants (column 9, line 4).

As a result, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to select the proper proportions of pH adjuster and surfactant to effectively control the solution properties in order to accomplish the desired etch results (smoothness), because it has been held that there is no invention where the difference in proportions is not critical and was ascertained by routine experimentation because the determination of workable ranges is not considered inventive.

As to claim 14, a difference is noted between the teaching s of Uozumi and appellant's claimed invention. Uozumi's method, cited above, fails to disclose a specific process time range for solutions 1 and 2 as appellant's claim 14 describes.

Kondo et al. disclose a polishing solution comprising a mixture of citric acid and aqueous hydrogen peroxide. The time cited for a specific example was 400 seconds, which is in the range specified in appellant's claim 14. In addition, oxidation and etching times depends on the initial thickness and the exact specification for the desired results.

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to specify a time for oxidation based on desired results including thickness to be removed and smoothness (as disclosed by Kondo et al.), and a time for oxide removal based on the desired quality of the final etched surface. One of ordinary skill in the art would have been motivated to determine, through routine experimentation, the process time for each step depending on the desired results.

As to claim 16, a difference is noted between the teaching s of Uozumi and appellant's claimed invention. Uozumi's method cited above fails disclose a specific R_{tm} Kondo et al. describe a polishing solution with 30% aqueous H2O2, and 0.03 wt % citric acid (column 12, lines 32 and 48). Kondo also fails to specify a surface Rtm. However Kondo et al. discuss critical parameters for obtaining a smooth surface.

As a result, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to select the proper parameters such as pH, temperature and oxidation time, to experimentally select the degree of smoothness as specified by other requirements.

Claim 12 is rejected under 35 U.S.C. 103(a) as being unpatentable over Uozumi (US 6261953) in view of Kondo et al. (US 6596638) and further in view of Miller (US 6719920).

Uozumi's method cited above fails to disclose specific proportions of organic acid, water, biocide and pH adjuster.

Kondo describes a polishing solution with 30% aqueous H2O2, and 0.03 wt % citric acid (column 12, lines 32 and 48) which is in the in the range of the appellant's claim 12, for organic acid and water. Kondo fails to teach specific proportions for biocide and pH adjuster but do illustrate the benefits of adjusting the pH (column 5, line 3).

Miller discloses that the addition of biocides (column 4, line 15) may help eliminate, from a solution, organisms that could yield undesirable results, but does not specify the proportions to be used in the above solution.

As a result, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to select the proper proportions of pH adjuster and biocide to effectively control the solution properties in order to accomplish the desired etch results (smoothness) and an organism free solution, because it has been held that there is no invention where the difference in proportions is not critical and was ascertained by routine experimentation because the determination of workable ranges is not considered inventive.

Claim 13 is rejected under 35 U.S.C. 103(a) as being unpatentable over Uozumi (US 6261953) in view of Kondo et al. (US 6596638) and further in view of Shimazu et al. (US 6547843.

Uozumi's method has been described above. A difference is noted between the appellant's claim and the references of Uozumi and Kondo et al. both Uozumi and Kondo et al. references fail to include a second acid in the second solution.

Shimazu et al. disclose a copper polishing solution including one or more organic acids (e.g. acetic acid, citric acid, etc.) (column 5, line 21).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the process of Uozumi, as described above, to include at least two organic acids to obtain a solution where the combined action of the acids yields a better copper etch by adjusting selectivity as different materials are used as dielectric isolation, also different acids have different reactions with different copper compounds. One of ordinary skill in the art would have been motivated to combine the teachings for a two-step method and the advantages of combining organic acids in order to obtain a smoother surface and control selectivity.

Claims 17-20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Uozumi (US 6261953) in view of Kondo et al. (US 6596638), and further in view of Singh at al. (US 6594024).

The references of Uozumi and Kondo et al. have been discussed above. A difference is noted between the appellant's claims and the reference of Uozumi. and Kondo et al. wherein the disclosures do not include a monitoring or endpoint method.

Singh et al. teach a method for monitoring a CMP polishing process using scatterometry, the disclosed method includes comparing the signature (column 14, line 58) associated with removing a layer to a signature library (column 14, line 61) for terminating a process when the desired depth is attained as in appellant's claim 17. Singh's method involves directing a beam of light at the processed layer and collecting a light reflected from the processed layer (column 3, line 50) and transforming the signal into a signature as in appellant's claim 18.Singh's method also includes a closed loop feedback control system (column 14, line 63), and it is capable of endpoint functions (column 2, line 47) including layer profiles as in appellant's claims 19 and 20.

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to incorporate Singh's control system into the modified teachings of Uozumi's to allow for etch process control. Endpoint detection and control systems are commonly used in semiconductor etch, CMP, and deposition technologies.

Claims 4,6 and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Uozumi (US 6261953) as applied to claim 1,2,3,5,7,8,9,10,11,14 and16 above, in view of Kondo et al. and further in view of APA (admitted prior art).

With respect to claims 4, 6 and 15, the modified teachings of Kondo are silent regarding the presence of surfactants, however, appellant admitted prior art specifically cite that surfactants (US 6596638), are known in the art (Page 8, line 9).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to further modify the method of Uozumi to include surfactants in the solutions, because surfactants enhance surface reaction for etching and oxide removal. It would have been obvious to one skilled in the art to add a surfactant to the solutions to obtain a smoother surface.

(10) Response to Argument.

Appellant argues on pages 4-10 that that one skilled in the art would not have modified Uozumi in the manner proposed by the examiner, this is not persuasive because the modified method proposed by the examiner allows a more stable process obtained with chemical solutions taught by Uozumi and Kondo. Uozumi clearly teaches two-step copper film etching is conventionally used in the art, the first step modifies a thin layer on the copper surface, the second step removes the modified layer on the copper surface.

The examiner cites, a difference is noted between the appellant's claims and the reference of Uozumi. Uozumi's first solution comprises ammonia, hydrogen peroxide and water, whereas the appellant's first solution comprises a first organic acid, a peroxide compound and water.

Kondo at al. teach an abrasive free polishing method wherein copper is removed using a polishing solution comprising an oxidizer and a substance that renders the oxidized copper water soluble, in particular, a mixture of citric acid and aqueous

hydrogen peroxide is cited as being a typical example of a polishing solution. The examiner maintains one of ordinary skill in the art would have been motivated to replace the first solution of Uozumi with the solution of Kondo in order to obtain better control of the etch stability. Kondo's teachings also include organic acids are substances that render copper and copper oxide water soluble (column 6, line33, and column 12, line29). One of ordinary skill in the art would have been motivated to combine the teachings for a two-step copper etch method and the advantages of organic acids in order to obtain an abrasive free controllable copper etch method that provides scratch free smooth surfaces.

As to appellant's argument that Kondo teaches against the use of citric acid-hydrogen peroxide solution for the purposes of forming an insoluble passivation layer, this is not persuasive because Kondo does not explicitly teaches against the use of citric acid-hydrogen peroxide solution for the purpose of forming a passivation layer, Kondo merely cites an example where a citric acid based solution is in the domain of corrosion (figures 9 and 26). Kondo shows Cu2O passivation corresponding to a pH ranging from about 5.8 to 14 (figure 9) which overlaps appellant's range of pH "about 2 to about 6".

As to appellant's argument citing there is no suggestion in Kondo that passivation layer may be formed using an acidic solution, this is not persuasive because Kondo cites "The solid line shows the corrosion rate (which is a form of passivation) when the oxidation-reduction potential is the same for the citric acid-based polishing solution and the aminoacetic acid-based polishing solution in FIG. 9. " (column 5, line 19).

As to appellant's argument about computer controlled process and monitoring does not require process stability, this is not persuasive, the examiner maintains that even with computer controlled process and monitoring, it is still preferable to have a stable process and operate in a process region where the etch rate does not change substantially when the pH changes by a small amount, process stability is desirable since it insures minimum variability in the etch results and product performance. Process stability is not irrelevant, even if the process is controlled and monitored.

As to appellant's argument about the modification of the second solution of Uozumi contradicts basic requirements of the second solution of Uozumi, this is not persuasive because a change of the first solution of Uozumi would have necessitated a change of the second solution since the second solution is intended to remove the passivation layer formed by the first solution, here again the examiner maintains that it would have been obvious to one of ordinary skill in the art at the time of the invention was made to modify the two step process of Uozumi by replacing the composition of each step with a composition that improves the over-all polishing results, Kondo's teachings also include organic acids are substances that render copper and copper oxide water soluble (column 6, line33, and column 12, line29). One of ordinary skill in the art would have been motivated to combine the teachings for a two-step copper etch method and the advantages of organic acids in order to obtain an abrasive free controllable copper etch method that provides scratch free smooth surfaces.

(11) Related Proceeding(s) Appendix

No decision rendered by a court or the Board is identified by the examiner in the Related Appeals and Interferences section of this examiner's answer.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

Mahmoud Dahimene.

Conferees:

Nadine Norton. - SPE 1765

Kathryn Gorgos.